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THE CHEMISTRY OF ESSENTIAL OIL AND ITS ROLE AS NATURAL FRAGRANCES IN PERFUMES

Sujata Sengupta[1] | Shivani Singh[1] | *Sharda Mahilkar Sonkar[1] | Anand Sonkar[2] | Nandini Kapoor[3] | Garima Tomar[3] | Shweta Gaur[3] | Aditi Bajaj[3]

[1]Department of Chemistry, Miranda House, University of Delhi, Delhi-110007, India. (*Corresponding Author)

[2]Department of Botany, Hans Raj College, University of Delhi, Delhi-110007, India.

[3]Department of Chemistry, Hindu College, University of Delhi, Delhi -110007, India.

ABSTRACT

Human beings have always been fascinated with the chemistry of fragrances. Since the earliest of times, man has always been interested in imitating nature's pleasant smells, to find methods to mask or augment their own body odour through the application of perfumes. Traditionally, perfumes comprise of a blend of natural components which together affords the unique pleasant odour. Modern day perfumery is a fusion of art, science and technology, with chemistry as the central science. Majority of the perfumes used today are based on the application of synthetic aroma bearing molecules made available by advances in synthetic organic chemistry. However, with the recent revival in popularity of the use of natural ingredients in cosmeceuticals, this review aims to re-look the chemistry of essential oils and its role as a natural source of fragrance. Development in methods of isolation and extraction of the natural odour bearing compounds are key factors responsible for the growth and development of the perfume industry.

INTRODUCTION:

The culture of fragrances can be traced back to the ancient past. The Egyptians, Greeks, Chinese and Indians; all have voyaged deep into the art of aroma. Scents including Jasmine, Rose and Sandalwood have been narrated in the Vedas, the oldest manuscripts in Indian history.[1] The word perfume originates from the Latin word "*per fumum*" meaning "through smoke" and refers to substances that emit and diffuse a pleasant and fragrant odour.[2,3] Chemistry has always played a major role in modern perfumery. Until the mid-19th century, the use of perfumes was limited to wealthy. Most perfumes are an amalgam of natural ingredients, mostly of plant origin, which together provides the unique scent. These odour bearing substances were found in limited supply and techniques used for their isolation were cumbersome, providing poor yields. However, with advances in modern synthetic organic chemistry, the industry at present has witnessed a real boom. Today, perfumes are used everywhere- from cosmetics products, to soaps and detergents and even in pharmaceutical formulations. Modern day perfumery now depends on the use of mixtures of both natural essential oils along with synthetic aromatic chemicals. A perfume consists of three basic components: the solvent - primarily a mixture of ethanol and water; fixatives - natural or synthetic substances used to stabilize the vapor pressure and enhance the overall odour; and essential oils - a complex mixture of odour bearing compounds.[4] The human body processes the scent in two ways, either through the olfactory system (which is directly connected to the brain) or/and by absorption of the essential oils through the skin.

This review articles aims to provide a brief overview of the science of perfumery, highlighting the role of essential oils as the major source of natural fragrances. Development in methods of isolation and extraction (solvent extraction, distillation, enfleurage, use of supercritical CO_2) of the odour bearing compounds is briefly discussed, a key factor responsible for the growth and development of the perfume industry.

PERFUMES:

Fragrances or perfumes play an ever-increasing role in the cosmetics industry. The simple addition of a sweet and pleasant odor, significantly influences the overall impact of the cosmetic product on the consumer.[5] Perfumes are defined as substances that emit and diffuse a pleasant fragrant odour. Typically, perfumes are volatile liquids and is usually a mixture of the fragrance bearing compounds (essential oils or the aroma containing compounds) mixed with fixatives and solvents.[6,7] Until the 19th century, perfumes were usually composed of natural aromatic oils (essential oils obtained from plants) but nowadays, are mostly mixtures of various synthetic "aroma" containing components, thanks to recent advances in synthetic organic chemistry.

Essential oils are a complex and diverse group of volatile and aromatic compounds produced by living organisms, primarily of plant origin. More than 4000 aromatic and medicinal plant species are known till date, providing oils which are an important source of fragrance and flavouring chemicals used in perfumery, food and pharmaceutical industries.[8] Chemically, essential oils are mixtures of several 'aromatic' or odour bearing compounds, including, terpenes, terpenoids (allylic, mono-, bi-, or tricyclic mono- and sesquiterpenoids) and other compounds such as phenylpropanoids, benzenoids, and low molecular weight aliphatic hydrocarbons.[9] Essential oils are readily soluble in organic solvents such as alcohol and ether but insoluble in water. They are usually colourless and volatile liquids at room temperature. Typically, essential oils are secondary plant metabolites produced in specialized secretory tissues/glands of various plants and certain animals. In addition to having a pleasant odour, essential oils are known to play key roles in the plant's defence mechanism and various signalling pathways.[10] The oils may be isolated from varying parts of the plants.[11] Lavender, rose and chamomile essential oils are isolated from the flowers of the respective plants, while lemongrass and peppermint oils are isolated from the leaves. Sandalwood, one of the most expensive essential oil, is commonly isolated from the bark of the sandalwood trees. A variety of methods exists for the extraction of these essential oils, including chemical methods such as steam distillation and solvent extraction, or mechanical methods such as expression (flower petals or fruit rinds/peels are physically crushed) and enfleurage (the essential oil is trapped within fat layers).[12] A few of the major essential oils most commonly used in perfumes and cosmeceuticals are listed in Table1.

Table 1: List of major essential oils commonly used in perfumes and cosmeceuticals

S. No	Essential Oil	Major Method of Isolation	Plant Part Used for Isolation	Major Constituent	Uses
1.	Bitter Almond	Distillation	Kernels	Benzaldehyde	Flavouring
2.	Bay	Distillation	Leaves	Eugenol	
3.	Cinnamon	Distillation	Bark	Cinnamaldehyde, Eugenol, Eugenol acetate	Used in Artificial flavouring
4.	Citronella	Distillation	Grass	Geraniol (60-90%), citronellal	Perfumery, Disinfectants
5.	Clove	Distillation	Bud	Eugenol (80-85%)	Dentistry, Flavouring
6.	Lemon	Expression	Peel	d-limonene (90%), citral (5%)	Flavouring
7.	Coriander	Distillation	Seeds	Linalool, pinene	Flavouring
8.	Sandalwood	Distillation	Wood	Santalols (90%)	Perfumery
9.	Rose	Distillation or solvent Extraction	Flower petals or buds	Geraniol, rose ketones,	Perfumery, flavouring
10.	Jasmine	Enfleurage	Flowers	Linalool, methylanthranilate	Perfumery
11.	Eucalyptus	Distillation	Leaves	cineale (70%) citronella, terpenes	Decongestant
12.	Lavender		flowers	Linalool	Perfumery

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A vehicle, or the solvent, is needed to keep the odoriferous substance in solution. A solution of the essential oil with the appropriate solvent is called a fragrance extract.[2,3] Generally, highly refined ethyl alcohol is the solvent of choice. Depending on the final use of the product, solubility characteristics of the essential oil and cost considerations, a small amount of water may be added to the alcohol.[13] Apart from its role as a solvent, the alcohol also contributes to the particular 'note' of the perfume- the various scent fractions of the fragrance.[4] Fragrances, particularly liquid based ones, can be objectively classified according to the varying ratio of the essential oil and the solvent (alcohol), highlighted in Table 2.[14,15] This classification essentially refers to the overall strength of the fragrance, dependent upon how much alcohol and/or water has been added to the essential oils. Parfum (generally the most concentrated form available) has nearly 15-30% of the essential oil dissolved in alcohol. Any mixture with a lower proportion of oil to alcohol is known as an *Eau*.

Table 2: Classification of fragrances based upon varying ratio of the essential oil and the solvent(alcohol)

Fragrance Type	% Essential Oil	% Alcohol
Perfume (Perfum)	15-30	90-95
Eau de Toilette	4-8	80-90
Eau de Parfum	8-15	80-90
Cologne Splas	1-3	80
Eau de Cologne	3-5	70

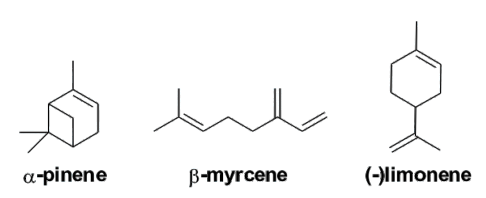
Fixative is term used for compounds that 'fix' and help the fragrance to last longer on the skin. Chemically, fixatives are natural or synthetic substances used to reduce the rate of evaporation of the overall perfume and improve the stability of the essential oil and thereby increasingthe overall shelf life of the perfume and help in the proper blending/integration of the aromas or scents.[2-4] Common natural fixatives include gums and resinoids (benzoin, labdanum, myrrh, olibanum, storax) and animal products (ambergris, musk and civet). Synthetic fixatives include odorless solvents with low vapor pressures (benzyl benzoate, diethyl phthalate, etc.) and substances of low volatility (benzyl salicylate, ambroxide, etc.).[16]

Composition of Essential Oils:

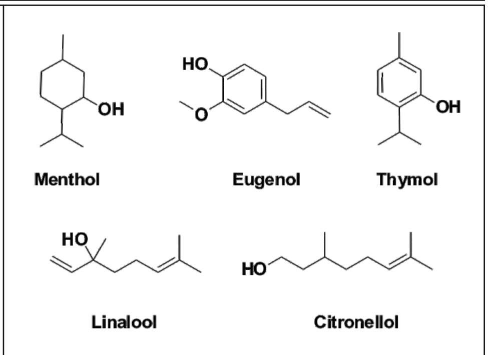
Essential oils are concentrated hydrophobic liquid containing volatile odoriferous compounds derived from the different parts of the plants. A particular essential oil can be composed of several components in varying composition, with two or three major components being present at high individual concentrations (20–70%), compared with the other components which may be present in trace amounts.[30] The overall fragrance of the essential oil relies on the specific odour of the individual components, which is determined by its structure and volatility. According to their chemical structure, these odour bearing compounds can be divided into four major groups: terpenes, terpenoids (allylic, mono-, bi-, or tricyclic mono- and sesquiterpenoids), phenylpropanoids, and "others" (benzenoids, low molecular weight aliphatic hydrocarbons, etc.).[31] Furthermore, these components consists of diverse functional groups, ranging from hydrocarbons (monoterpenes, sesquiterpenes, and aliphatic hydrocarbons), oxygenated compounds (monoterpene and sesquiterpene alcohols, aldehydes, ketones, esters, and other oxygenated compounds); and sulphur and/or nitrogen containing compounds (thioesters, sulphides, isothiocyanates, nitriles, etc.).[32]

Terpenes constitute the largest group of natural fragrances. Chemically, terpenes are a class of hydrocarbons occurring widely in plants and certain animals. Their classification is based on the number of isoprene (C_5H_8) units present in their structure - hemiterpenes (C_5), monoterpenes (C_{10}), sesquiterpenes (C_{15}) and diterpenes (C_{20}).[2-4] Monoterpenes ($C_{10}H_{16}$), diterpenes and sesquiterpenes ($C_{15}H_{24}$) are most abundant in the essential oils from plants. Common examples include monoterpenes myrcene and limonene and sesquiterpenes -himachalene. Oxygenated derivatives of terpenes are commonly known as terpenoids and are another major component of essential oils. Linalool, citronellal, citral (geraniol and neral) are some of the major terpenoids widely abundant in essential oils and extensively used in the perfume industry (see Figure 1). Esters of anthranilic acid, salicylic acid and benzyl alcohol are example of benzenoids found as major components of certain essential oils. Methyl anthranilate, amyl salicylate, methyl salicylate and benzyl cinnamate are common examples. Eugenol, anethole, and myristicin are examples of phenylpropanoids, another class of compounds found in certain essential oils. Phenylpropanoids, also a class of secondary plant metabolites, are a diverse group of compounds derived from the carbon skeleton of phenylalanine that are involved in plant defense, structural support, and overall survival of the plant.[33,34]

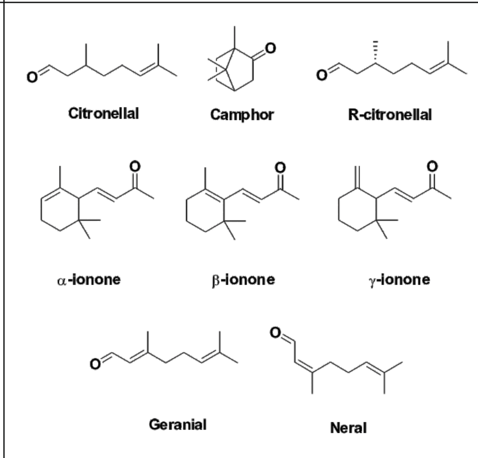
Terpenes



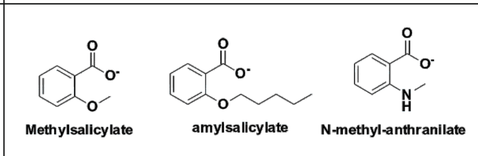
Alcohols



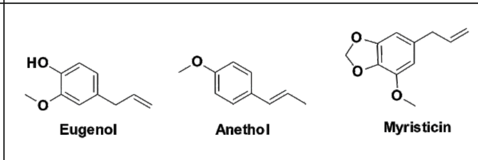
Aldehydes/Ketones



Benzenoids



Phenylpropanoids



Components from animals

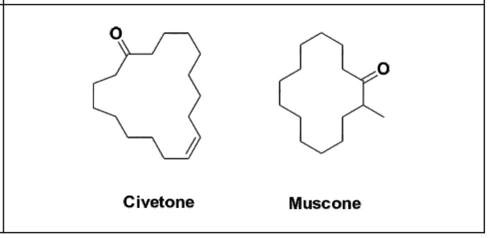


Figure 1: Structures of common components of essential oils

Various Methods of Isolation of Essential Oils:

"Aroma Extraction or fragrance extraction" commonly refers to the extraction of the odoriferous "aromatic" compounds from raw materials using common methods such as distillation, solvent extraction or expression.[17] The ultimate essence obtained has many different terms -essential oil, concrete, absolute, etc. In general, the major methods routinely used for the isolation of volatile oils from plants include: expression, distillation, extraction with volatile organic solvents and absorption in purified fats (enfleurage). Each method has their own distinct set of advantages and drawbacks. The methods, though popular, may also prove to be damaging- where the odoriferous compounds get denatured during the extraction process due to heat, exposure to oxygen or chemical reaction with the solvent. This may produce an extract with an aroma distinct from the aroma of the raw materials or render them completely odourless.

Extraction with Volatile Solvents:

Solvents such as hexane, purified petroleum ether and ethanol are generally used for the extraction of essential oils from the plant material by solvent extraction.[1] It is one of the most common and economically important technique of extraction in the modern perfume industry. The raw materials are submerged and agitated in the suitable solvent to allow dissolution of the odoriferous components. Criteria for the selection of a suitable solvents include: high selectivity (the solvent should be capable of dissolving only the odoriferous component), a low boiling point (easy and complete evaporation of the solvent without leaving any residue behind once the extraction is complete), chemical inertness to the odoriferous

components, cheap and inflammable. A typical solvent extraction method first involves treatment/agitation of the plant material with a suitable organic solvent. The desired aroma containing compounds dissolve, after which the solution of the aromatic substances is evaporated to produce a “oleoresin or concrete" (a waxy semi-solid residue containing the essential oil, waxes and resins). The concrete is often mixed with alcohols to remove the unwanted waxes and resins. The alcohol is then removed by a second distillation, leaving behind the pure essential oil called the “absolute”.[1,2] Extracts from plants such as jasmine and rose, are called absolutes. The solvent used during the extraction process is usually condensed, rectified and reused for a second batch. Though the method is used to extract essential oils from plants, it is best suited for those oils isolated from animal secretory glands, such as civet and ambergris. It produces a finer fragrance as compared to any type of distillation method.[18]

Expression:

Expression is one of the most traditional yet common method for the extraction of essential oils. Expression, also termed as "expeller-pressed" or “sponge process” involves the pressing, squeezing or compression of the raw plant materials to extract the essential oil.[1,2] Since no heat is required during the extraction process, it's also known as “cold-pressed” method. Today, the method is most commonly used for the extraction of essential oils obtained from peels of fruits of the citrus family.[18] Traditionally, the citrus fruit peels were soaked in water after which the peels would be pressed against a sponge. Once the sponge is saturated with the oil, it is hand squeezed to release the essential oil. Modern expression now involves mechanical or cold pressed techniques. The *pelatrice* and *sfumatrice* processes are most popular mechanical processes for citrus oil isolation in Italy.[19] In the simplest mechanical method, the entire fruit is placed in an expression machinery where it first pricks the surface of the peel. As this process occurs, small sacs containing the essential oil break open and releases the oil. Water is then sprayed over the fruit to collect the essential oil. At this stage however, the essential oil may be mixed along with some additional watery materials from the fruit's flesh. To isolate the essential oil, the mixture is either filtered and centrifuged to separate out the pure essential oil product or the oil is forced out from the material under high mechanical pressure. Expression usually provides a high quality of the final product with characteristic fragrances identical to the starting raw materials. This method is especially beneficial for extraction of those essential oils that lose their fragrance when exposed to high temperatures in methods like steam distillation.

Distillation:

Distillation is the most popular method used to extract essential oils from plant materials. The process is particularly used for obtaining essential oils present in cumin, anise, lavender, rose, fennel, mace, and nut meg.[1,2] This method involves heating the volatile essential oils to their vapor state followed by condensation into the liquid state. There are various distillation techniques employed to obtain essential oils: water or hydro-distillation, steam distillation and hydro-diffusion, of which steam distillation is most widely accepted method on a commercial scale.[18] In this method, the plant materials are charged into large distillation containers called “stills” (nearly 600-gallon capacity tanks made of tin with a copper lining). Steam is injected through an inlet and distillation is carried out. The steam releases the essential oil from the plant feed, after which, it passes through a cooling system with a condenser, where the vapor mixture is cooled and collected in a 'separator'. The essential oil separates from the distillate and may be collected. Since the temperature never goes above 100 °C during the distillation process, heat and temperature sensitive essential oils may be easily extracted by steam distillation.[20,21] In the hydro-distillation technique, the plant material is completely submerged in sufficient quantity of water, and brought to a boil by applying direct heat. The essential oil distils out, along with water and then is separated after condensation. Water distillation is the most common method of distillation primarily due to the low costs involved. However, steam distillation boasts of a higher efficiency and a higher quality of essential oil extraction compared to water distillation, since the water and the plant feed are not directly in contact with each other.

Enfleurage:

Enfleurage is one of the oldest methods of extraction of essential oil from flowers with the use of fats.[1,2] However, with modern methods of extraction such as distillation and solvent extraction, it has lost its popularity. The fats used in this method are odorless and solid at room temperature. Once the fat is infused with the fragrance, it is referred to as "enfleurage pomade". Depending on whether heat is applied during the extraction process, enfleurage is of two kinds: hot or cold.[18]

In cold enfleurage method, a large framed plate of glass, the 'chassis' is smeared with a layer of the highly purified fat (usually animal fat such as lard) and allowed to set. Fresh plant raw material (flowers or petals) is placed on top of the layer of fat and are allowed to set for few days, to allow the scent to diffuse into the fat. The process is repeated with fresh plant feed till the fat reaches the desired saturation. The final product (the fat saturated with the fragrant oil) may either be used as is or the oils are captured by dissolving the fat in an alcoholic solvent. The alcohol evaporates from this mixture to leave behind the pure "absolute" essential oil. In hot enfleurage, a similar protocol is followed but the only difference being that the ingredients are stirred in hot animal fat until desired oil is obtained.[1] Enfleurage has certain drawbacks: the concentration of the odiferous oil is usually low, the fats are not a pleasant material to handle and often turns rancid after repeated use.

Innovative Techniques for Green Extraction:

Supercritical Fluid Extraction:

With increased interest in cleaner and greener methods of separation techniques, supercritical fluid extraction has gained much popularity in the food and flavouring industry, especially for the decaffeination of coffee and tea.[22] Supercritical fluids, above their critical points, exhibit properties characteristic of both liquids (high solvating power) and gases (high diffusivity and low viscosity). Solvents like CO_2, butane and ethylene are now commonly used in their supercritical states for various industrial applications. CO_2, in particular, is the supercritical solvent of choice, since it is an odourless, colourless, non-toxic, non-flammable and recyclable gas, whose supercritical state is reached at relatively low pressures and near room temperature ($T_c = 31.2\,^oC$ and $T_p = 7.3$MPa). Not only does it behave as a lipophilic solvent, its solvating power may be tweaked as par requirement.[23] SFE, has also been explored for the extraction of fragrances from plant materials. Conventional extraction techniques, such a solvent extraction and distillation, though extensively used, have several drawbacks: low selectivity, high energy requirements and a possible loss of the volatile essential components. Extraction of essential oils with supercritical CO_2, therefore, provides an attractive and green approach for the isolation of fragrances, especially for eucalyptus and lavender oil.[24,25]

SFE with CO_2 typically involves a semi-continuous batch process.[1,18,26] The extraction vessel is charged with the dried and finely powdered plant feed, after which, the supercritical solvent is continuously loaded from the bottom of the vessel. The supercritical fluid along with the extracted plant extracts then exit the vessel through a depressurization valve into a separator. Due to low pressure, the extracted essential oils separate from the gaseous CO_2 solvent and are collected. The gaseous solvent is usually recycled back into the system. Lavender essential oil, may be extracted from Lavandin (*L. hybrida*) flowers with SFE using the following conditions: temperature at 90.6 °C, pressure at 6.3 MPa and solvent flow rate of 0.2 mL min^{-1} to provide separation of the odoriferous constituents of 1,8-creole, linalool, linalyl acetate and camphor, which is commonly used by the food and fragrance industries.[27]

Microwave-Assisted Extraction (MAE):

Conventional extraction processes usually require the use of massive energy. In order to reduce this energy consumption, one can assist existing processes with intensification technologies to produce high-quality innovative fragrance extracts. Activation technologies, particularly microwaves, enable the development of solvent-free industrial processes, an even more advantageous and greener alternative.[28]

Microwave-assisted extraction (MAE) is a relatively new extraction technique, combining the power and principles of microwaves with traditional solvent extraction. The solvents along with plant tissues, containing the natural products, are heated during the extraction with microwaves. MAE has several advantages over traditional extraction techniques: higher extraction rates, shorter extraction time, use of less amounts of solvents, and lower costs. The use of MAE for the isolation/extraction of essential oils has gained much popularity in recent times.[29] Several modified versions of MAE methodologies exist, including pressurized microwave-assisted extraction (PMAE) and solvent-free microwave-assisted extraction (SFMAE). In SFMAE, the plant feed is placed in the microwave reactor without the addition of any solvent (water or organic solvents).[18] The microwave expositions result in the heating of the internal water of the plant matrix, rupturing the glands and releasing the volatile essential oils, which get evaporated. The vapours are then cooled and condensed in a cooling system located outside the microwave and collected in special glassware. The excess water may be refluxed and recycled back to the extraction vessel. Furthermore, the extracts are obtained in high yields and are free from any contaminants. Because of the shortened extraction times, this method is environmentally friendly. However, essential oils containing odoriferous components composed of low boiling point hydrocarbons do tend to undergo decomposition.

Major Essential Oils in India:

India is currently one of the world's largest producer and exporter of essential oils and their value-added products.[35] Boasting of a rich biodiversity, large scientific manpower and modern industrial set up, the essential oil cultivation and processing has seen tremendous growth over the years. Many aromatic plants have been introduced and successfully cultivated in India (menthol, lemongrass, citronella etc.). A few of the major essential oils produced in India are highlighted below.

Rose Oil:

Rose oil, also known as rose otto or attar of rose or rose absolute, is the most widely used essential oil in perfumery and cosmetics. Two major species of roses are cultivated for the production of rose oil- *Rosa damascena* (or damask rose, found in India, Turkey, Bulgaria, etc.) and *Rosa centifolia* (found mostly in Egypt and France). The production of rose oil is a labour-intensive process, especially due to the low content of the oil in rose blooms (0.03-0.04%). The oil is extracted from the rose bud and petals, where nearly 3.5 tons of rose petals produce only 1 kg of rose otto.[36]

Components:

The chemical composition of rose oil is quite complex and consists of more than 300 known compounds. The most common chemical components present in the rose oil are - citronellol, phenyl ethyl alcohol, geraniol, neral, nonadecane and farnesol along with traces of linalool, nonanal, phenyl acetaldehyde, citral, carvone, eugenol and rose oxides. The major components of rose water volatiles obtained from the bud and full bloom stages of *Rosa damascena Mill.* from cultivar 'Ranisahiba' in Uttarakhand, India was phenyl ethyl alcohol (66.2–79.0%), geraniol (3.3–6.6%) and citronellol (1.8–5.5%).[37,38]

Method of Extraction:

The main industrial products are rose oil, rose water, rose concrete and rose absolute, all of which are produced by hydro-distillation and solvent extraction processes. Rose otto essential oil (or Attar of Rose) is a product isolated during steam distillation and is a light-yellow aromatic liquid (crystallizes at low temperatures) and is used widely in the fragrance and food flavouring industry. In the distillation method, fresh rose blooms (picked before sunrise) are agitated along with water in large stills or vats and steam-heated. The vapours containing the rose oil then enters the condensing chamber, are condensed and separated to collect the concentrated rose oil, also known as “direct oil”. The water-soluble portions are repeatedly distilled to obtain the “indirect oil”. The direct and indirect rose oils are combined and afford the final rose oil (Rose Otto or Attar). The hydrosol portion of the distillate, commonly known as rose water, is an inexpensive by-product widely used in food flavouring and skin care products. Rose Otto has a more delicate aroma and expensive as yields are generally low.

Rose Absolute is the aromatic oil obtained from the fresh petals of the Damask Rose (*Rosa damascena*) by solvent extraction. Highly popular in the perfume industry, rose absolute is a viscous, golden amber coloured concentrated oil with a strong and intense rose odour. In the solvent extraction method, the fresh rose blooms are agitated in large vats with an organic solvent, usually hexane, which draws out the aromatic compounds along with other soluble substances such as waxes and pigments, as well. The extract is then subjected to a vacuum procedure that removes the solvent for re-use. The waxy mass which remains is termed concrete. The rose concrete is agitated with alcohol at low temperatures (-15 °C to -20 °C) due to which the aroma containing components dissolve, leaving behind the wax impurities. The alcohol is evaporated under low-pressure conditions and rose absolute is obtained as the final product. Rose Absolute is extremely concentrated and reflects more of the true 'Rose' odour compared to rose otto.

Uses:

Rose oil is a common component in a variety of cosmetic products, such as soaps, powders, creams, etc. Rose oil has various anti-inflammatory and nourishing properties as well. It helps in healing and protecting the surface of the skin, thus providing a youthful complexion. It's known to possess antidepressant and therefore is commonly used in aromatherapy to help soothe the mind. Rose oil is also known to possess antiseptic and antiviral properties.

Sandalwood Oil:

Sandalwood oil is the essential oil obtained by steam distillation of the chips of the heartwood of various species of the sandalwood trees of the Santalum species, Santalum album (Indian Sandalwood) and Santalum spicatum (Australian sandalwood).

Components:

Sandalwood oil comprises of more than 90% sesquiterpene alcohols, α-santalol (50-60%) and β-santalol (20-25%), responsible for the pleasant and characteristic aroma of the oil.[39,40] S. album heartwood is known to contain the highest concentration of the oil and the highest proportion of the santalols. The composition and oil content depends on the species, region grown, age of tree, the season of harvest and the extraction process used.[41]

Method of Extraction:

Hydro-distillation is the conventional method of extracting sandalwood essential oil. The powdered wood is soaked in water and boiled over an open fire. The oil floats to the surface, above the hydrosol, and collected. However, the process is time consuming and requires heating a huge quantity of water, raising the cost. Furthermore, the heat often "burns" the oil, making its quality poor. Modern methods of sandalwood oil extraction involve steam distillation and supercritical CO_2 extraction. In steam distillation, super-heated steam is passed through the powdered heartwood after which the steam rich in sandalwood oil is cooled to obtain the sandalwood hydrosol and sandalwood essential oil. Typically steam distillation yields 3.6% of oil after 24 h of distillation. Recently, sandalwood has been extracted with subcritical CO_2 (at 200 bars and 28 °C), proving to be more efficient than steam distillation, providing a yield of 4.11% of the oil in the first hour.[42]

Uses:

Sandalwood oil is an excellent, mild and long-lasting sweet fragrance used widely in perfumes and cosmetic products. It also serves as an excellent base and fixative for other high-grade perfumes. In addition, sandalwood has antipyretic, antiseptic and diuretic properties and has been used in Ayurvedic medicine for the treatment of headaches, stomachache, and urinary tract infections.[43]

Peppermint Oil:

Peppermint (*Mentha piperita L.*) is a perennial aromatic herb belonging to the Lamiacae family, native to the Mediterranean regions, but now cultivated all over the world. Peppermint is one of the most useful medicinal and aromatic plants. Members of this mint family are characterized by their volatile oils, peppermint essential oil, used widely by the flavoring, perfume and pharmaceutical industries.[44]

Components:

The most abundant odoriferous chemical compounds isolated from peppermint essential oils are oxygenated monoterpenes (72.34–86.41%), particularly, menthol (30-50%), a monoterpene alcohol, primarily responsible for the strong minty, cooling odour and taste characteristic to the oil.[45] Other major constituents of the oil include menthone, 1,8-cineole, neo-menthol and the carboxyl esters, menthyl acetate in particular. Peppermint oil also contains traces of terpenes such as limonene, pulegone, caryophyllene and pinene. The chemical composition of peppermint leaves may vary with plant maturity, geographical region, and processing conditions.[46]

Extraction:

Peppermint oil is extracted by three methods: solvent extraction, Soxhlet and steam distillation.[47] The isolation of peppermint oil by solvent extraction involves mixing the fresh and dry peppermint leaves with an organic solvent, ethyl alcohol, for several hours at slightly elevated temperatures. The solvent is then evaporated off to recover the oil. Steam distillation uses heat from steam or water to break the oil glands in peppermint leaves and vaporizes the oil, which is then condensed and separated from water. In the Soxhlet extraction, fresh and dry peppermint leaves are placed in the thimble of the Soxhlet apparatus, which is placed in a distillation flask, usually containing the solvent, hexane. After repeated extraction cycles, the desired peppermint oil concentrates in the distillation flask. After which, with the help of a rotary evaporator, the solvent is removed to yield the extracted oil.[48]

Uses:

Peppermint oil is extensively used in the food flavouring, perfumery and pharmaceutical industry. The oil adds a fresh, pleasing fragrance to soaps and other cosmetic products. It is also used as a flavouring agent in foods and in products such as mouthwashes. It is helpful in the treatment of irritable bowel syndrome (IBS), nausea, various digestive issues, as well as the common cold and headaches.[49]

Lemongrass Oil:

Lemon grass *(Cymbopogon citratus*), belonging to the Poaceae family, is a perennial grass with thin, long leaves and cultivated in tropical countries, especially in Southeast Asia.[50] This plant species is one of the main sources of lemongrass essential oil, generating nearly 1000 tons of the oil annually. The Lemongrass essential oil is extracted from the leaves of the plant and is widely used in the pharmaceutical, flavoring, perfumery/cosmetics, and agriculture industries.[51] The oil possesses a refreshing and calming aroma, leading to a pleasurable sensation.[52] Recent scientific studies have indicated lemongrass essential oil possess antioxidant, antimicrobial, antifungal, anti-inflammatory and anticancer activities.

Components:

The major odoriferous components present in lemongrass essential oil are terpenes limonene, β-myrcene, citral, geraniol, citronellol, neral and geranyl acetate. Limonene and β-myrcene are mostly responsible for the distinct odor characteristic to lemongrass. However, citral, is the predominant component of lemongrass essential oil. Citral is a mixture of two isomeric terpenoids (monoterpene aldehydes), neral, the cis isomer (25% to 38%) and geranial, the predominant trans isomer (40-62%) In general, the chemical composition of lemongrass oil varies, depending upon the habitat, growth conditions, the time of year the plant is harvested and extraction techniques used.[53] Furthermore, the quantity of citral present in lemongrass oil determines its quality, the higher the content of citral, higher the purity of the essential oil.[54]

Method of Extraction:

Lemongrass essential oil may be extracted by several different methods such as solvent extraction, steam or hydro distillation, and supercritical fluid extraction (SFE) using CO_2.[55-57] Isolation by solvent extraction involves mixing the plant material with an organic hydrocarbon, usually n-hexane, to dissolve the essential oil. Filtration followed by concentration by distillation to remove the solvent, leaves behind the essential oil. The method is efficient and simple; however, large volumes of the organic solvent is required and contamination of the essential oil with the solvent is common. The Soxhlet apparatus is also commonly used for solvent extraction of lemongrass essential oil.[58] The most popular method for the isolation of lemongrass oil is by steam and hydro distillation. In steam distillation, the steam passes through fresh or wilted lemongrass leaves, softening the cells to allow the essential oil to escape and vaporize. Subsequently, the steam and vapors of the oil are cooled in a condenser, separated and collected. Yields of lemongrass oil obtained by steam distillation ranges from 0.24% to 0.71%. Hydro-distillation of lemongrass is usually performed using a Clevenger-type apparatus where the lemongrass leaves are completely immersed in water and distilled upon heating.[59] The method is simple, cost effective and yields of the oil are

better (up to 1.80%). Modern methods of extraction involving microwave-assisted hydro-distillation and subcritical carbon dioxide extraction, are reported and promising, though the methods are expensive and yields are not significantly any better.[57]

CONCLUSION:

The chemistry of essential oils and its role in perfumes has always fascinated mankind. Modern day perfumery is mostly based on the application of synthetic aroma bearing molecules, made available by advances in synthetic organic chemistry. However, the use of essential oils from natural sources has seen a recent revival in its popularity. Its ability to impart a wide range of aroma along with medicinal properties has made them highly valued ingredients in perfumes and cosmeceuticals. Hydro- and steam distillation and solvent extraction are the preferred methods of extraction of essential oils for a very long time. Recent advances and innovation in cleaner, greener and more energy efficient extraction technologies, such as SFE and MAE, now provides a sustainable approach to the extraction of the natural ingredients. However, there is still a long way to go to before these techniques can become feasible alternatives to conventional methods.

Declarations:

Author contribution statement:

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